



Energy-Water Nexus: a National Laboratory Perspective

Presented by

Robin L. Newmark

Water and Environment Program Leader

Energy and Environment Directorate

Lawrence Livermore National Laboratory



Energy-Water Relationship Workshop

California Energy Commission

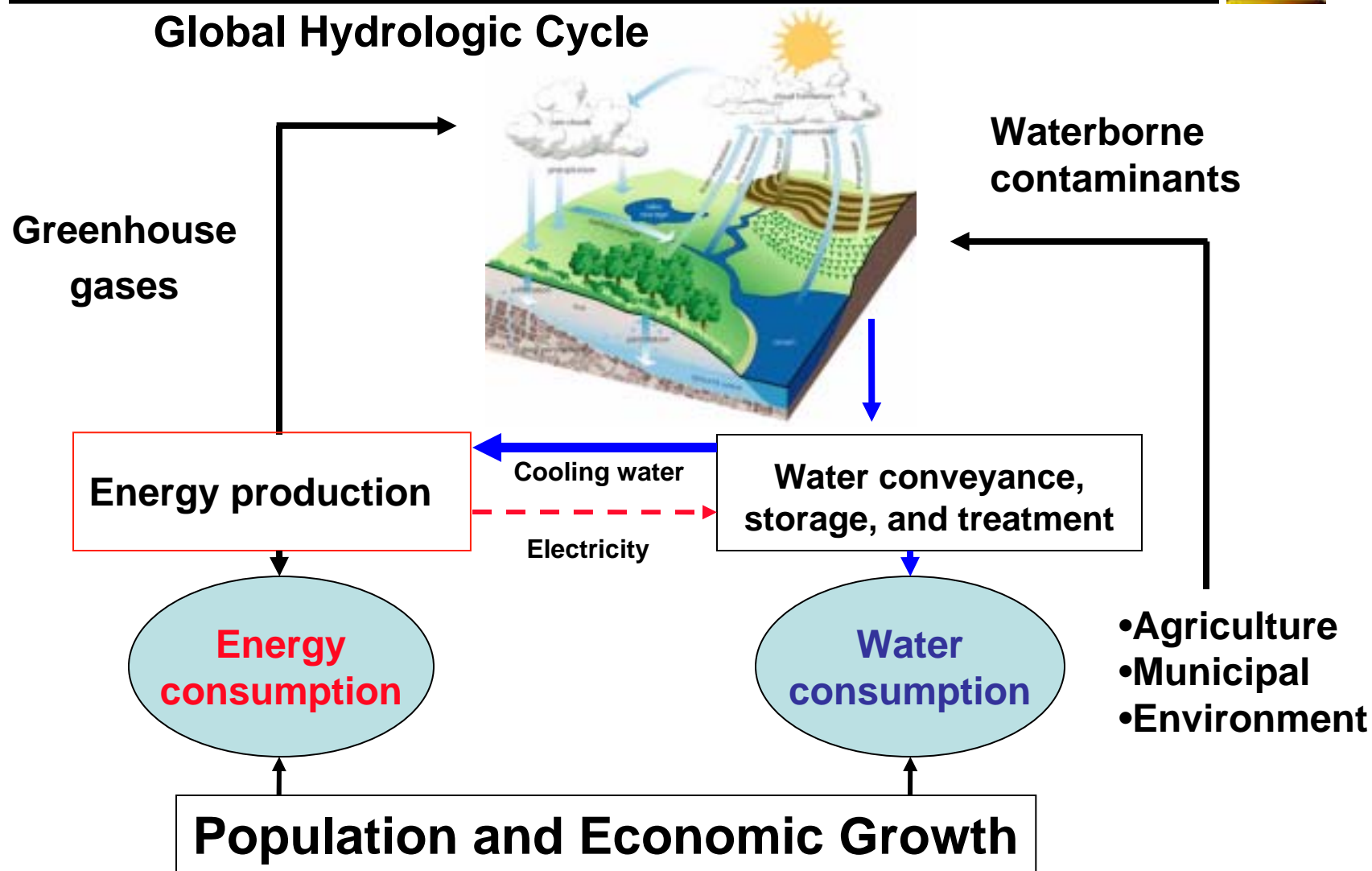
January 14, 2005



Energy/Water connection: Energy-water linkages are critical elements of economic and environmental systems



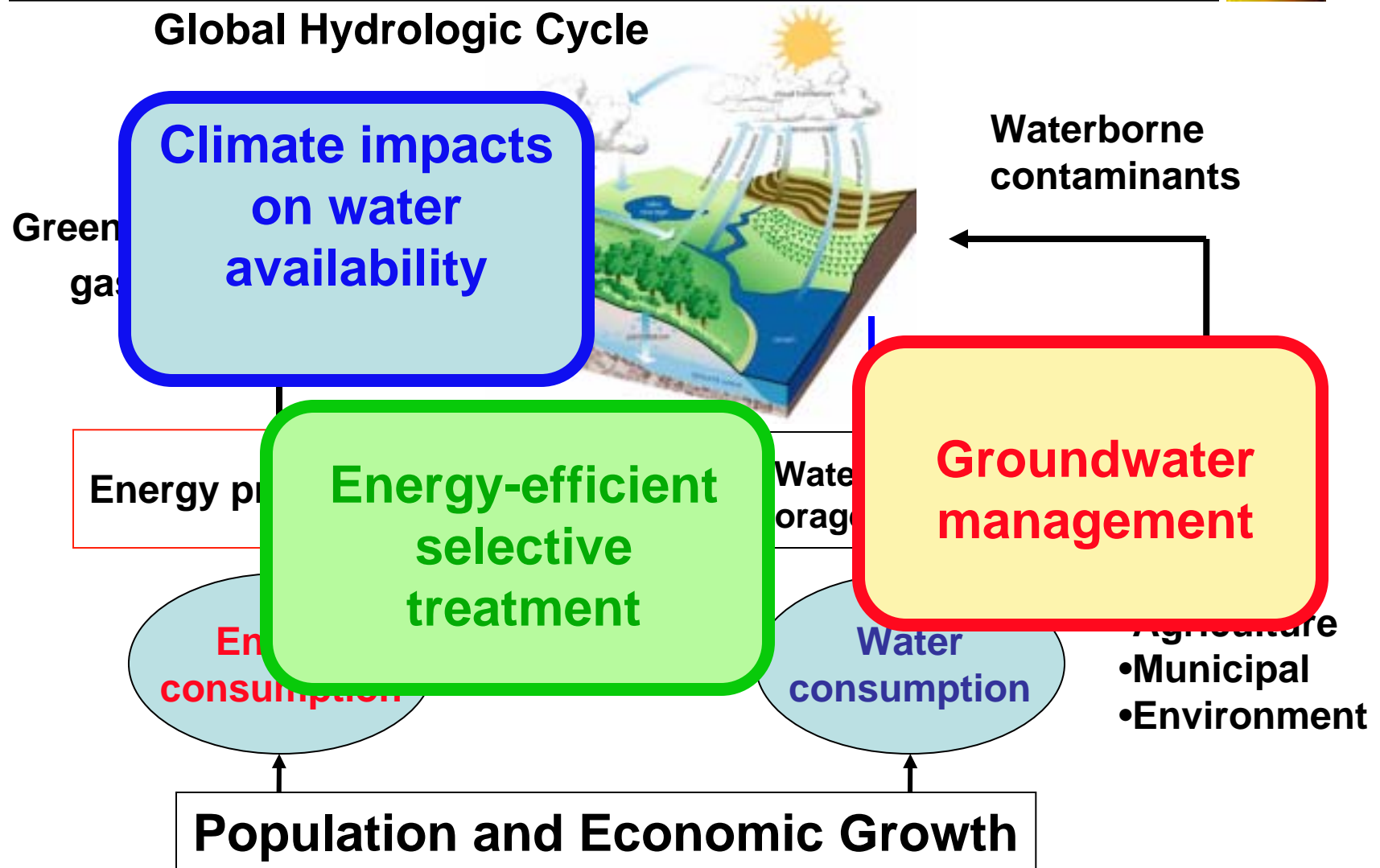
Global Hydrologic Cycle



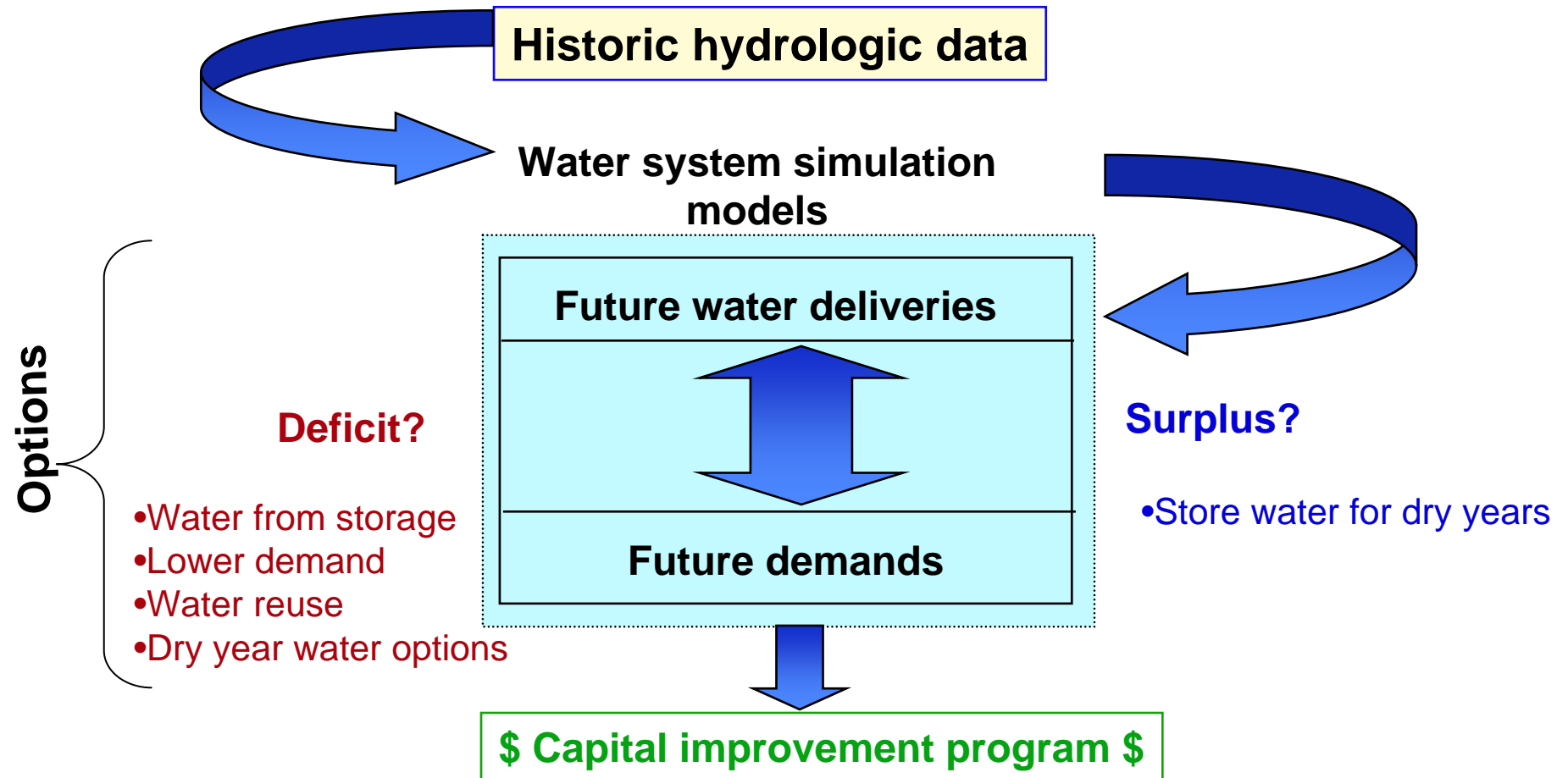
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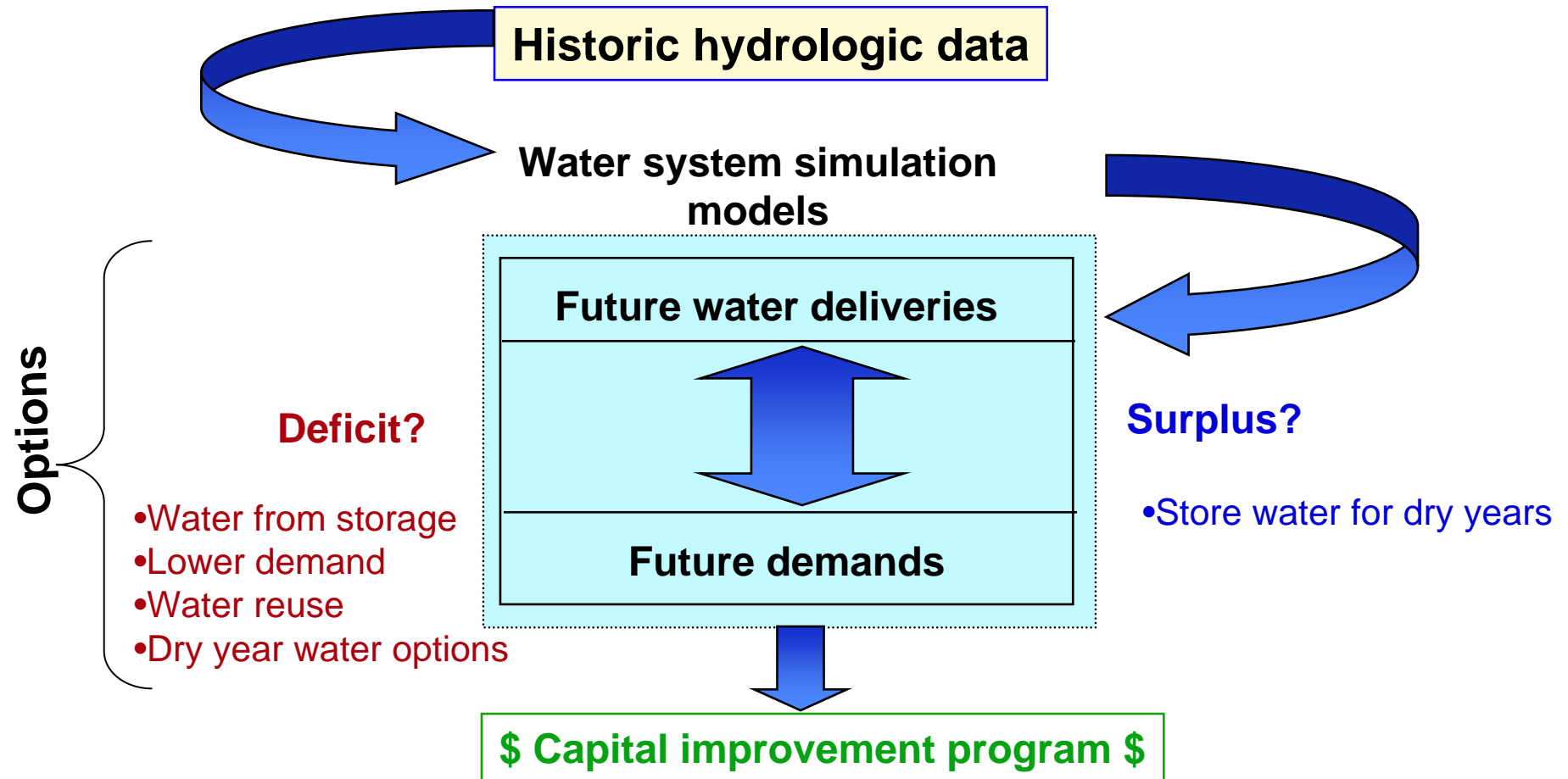
Global Hydrologic Cycle



Water management planning in California uses the past to predict the future

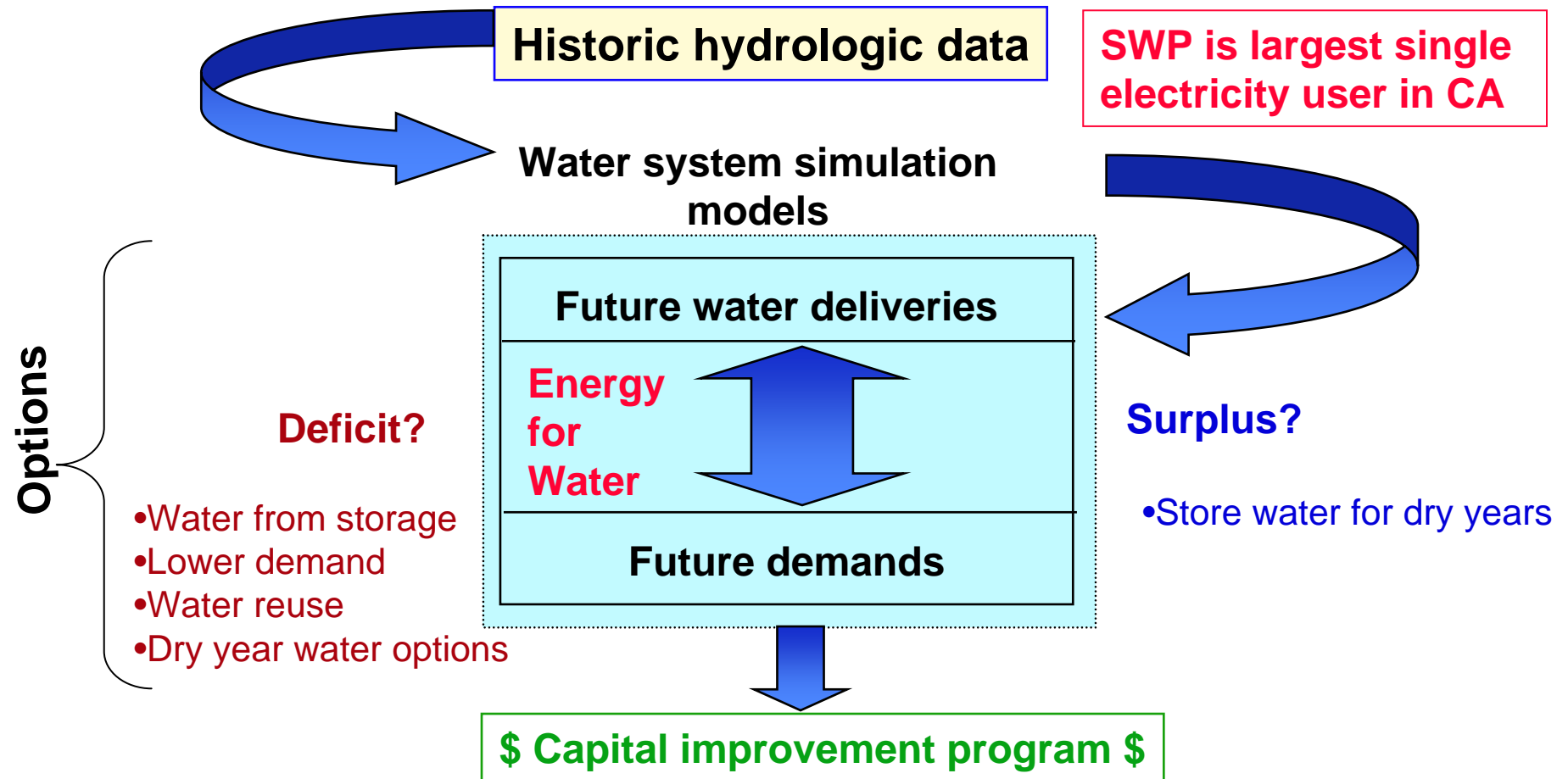


Water management planning in California uses the past to predict the future: *this may no longer be valid*



Water managers are making important infrastructure decisions today based on the historic hydrologic record; how can we address these changes in our management strategies?

Water management planning in California uses the past to predict the future: *this may no longer be valid*

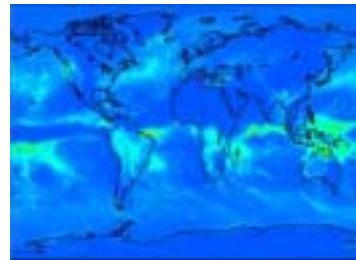


Water managers are making important infrastructure decisions today based on the historic hydrologic record; how can we address these changes in our management strategies?

LLNL's two-tiered approach: simulate CA climate and hydrology at high spatial resolution; estimate uncertainties

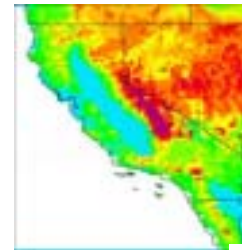


Global Climate Models



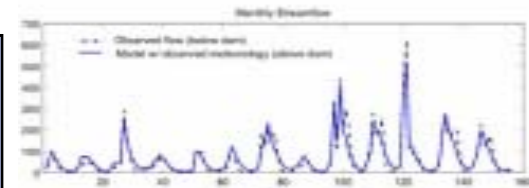
Grid size ~75 km

Regional Climate Models



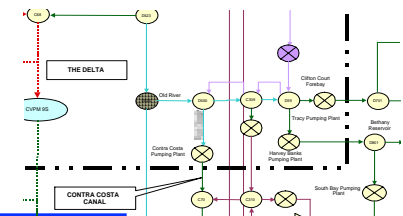
Grid size ~10 km

Surface Hydrology Models



Grid size ~5 km

Water Infrastructure Models (e.g., CALSIM)



Water and other agencies

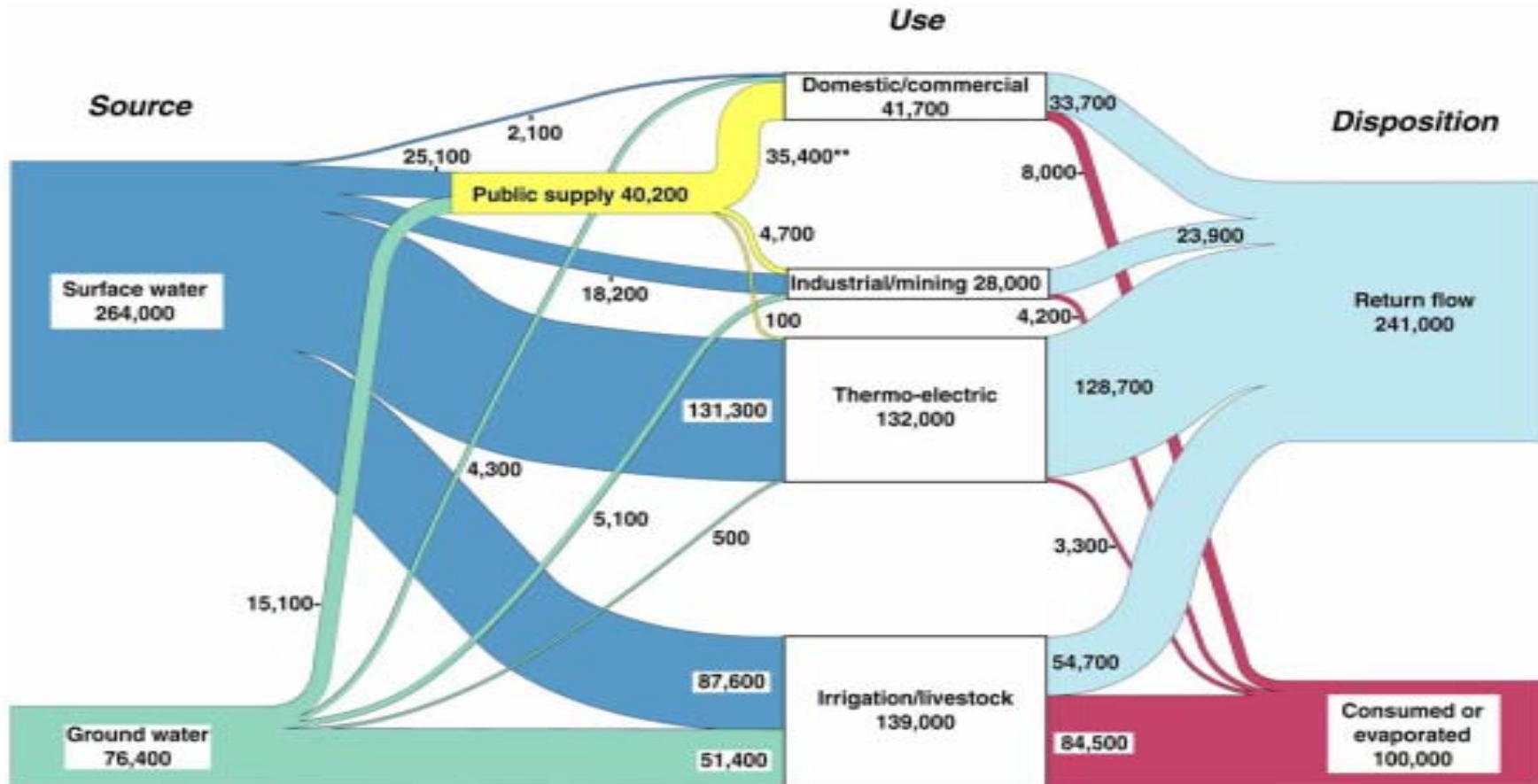


High resolution climate simulations are very computationally intensive

Nationally, we rely heavily on surface water, returning more freshwater than we consume



Estimated U.S. freshwater flows in 1995 (total ~341,000 Mgal/day)



Source: U.S. Geological Survey, Publication 1998-064214.

*In addition, 60,800 Mgal/day of saline water was withdrawn, primarily for thermo-electric use.

**Includes public use and losses of 5,990 Mgal/day.

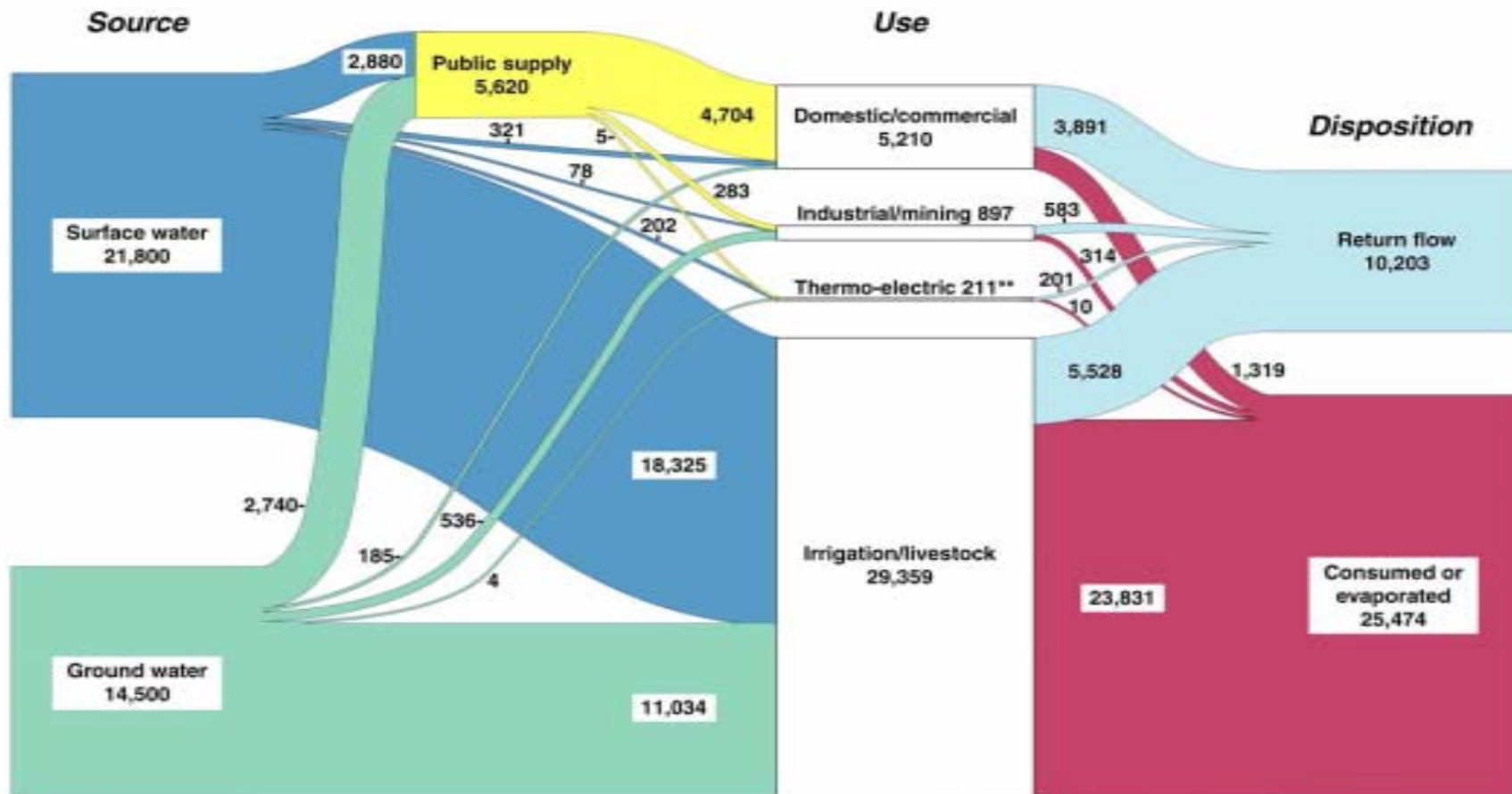
Note: Numbers shown may not add to totals because of independent rounding.

Lawrence Livermore National Laboratory, April 2003

California's freshwater use may be more indicative of future trends, including greater reliance on groundwater



Estimated California freshwater use in 1995 (total ~36,000 Mgal/day)



Source: U.S. Geological Survey, Publication 1996-054214.

**Difference between input and output of ~629 Mgal/day for public use and losses.

**In addition, 9,433 Mgal/day of saline water were used for thermoelectric purposes.

Lawrence Livermore National Laboratory, April 2003

Available potable water is decreasing due to increasing contamination



Nitrate

Max. 40 ppm

3000 nitrate contaminated wells in California



Arsenic

Max. 10 ppb

5% of US water supplies
\$1-4B for compliance in U.S.
137M people in Bangladesh



Perchlorate

6 ppb public health goal

DOD problem
Affects 350 wells in California
Colorado River has 4-6 ppb



Pathogens
viruses,
bacteria,
Protozoa

Reclaimed waste water from sewage plants demands removal of biological pathogens, endocrine disrupters, etc.

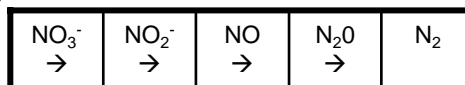
1. Management tools are needed
2. Large volume of “impaired” waters exist that need selective extraction for reuse

LLNL is developing tools and science-based models: *Enabling informed policy decisions for the future*



FIELD-SCALE REACTIVE TRANSPORT

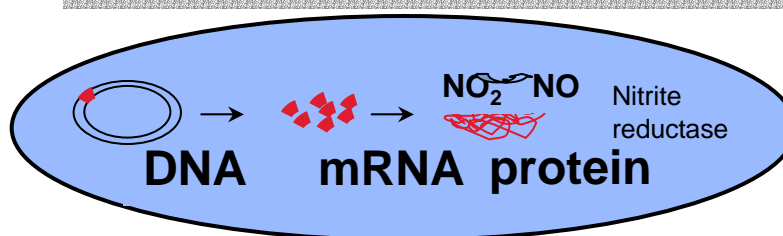
Dairy farmers, UC-Davis,
UC-Cooperative Extension,
State Water Resources Control Board (California EPA)



DATABASE MINING:

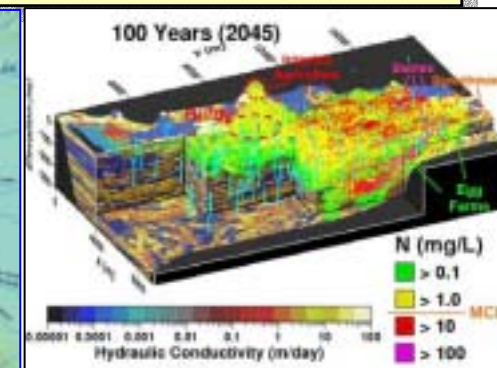
California Department of Health
Services database, GAMA

MICROBIAL CONTROL of DENITRIFICATION

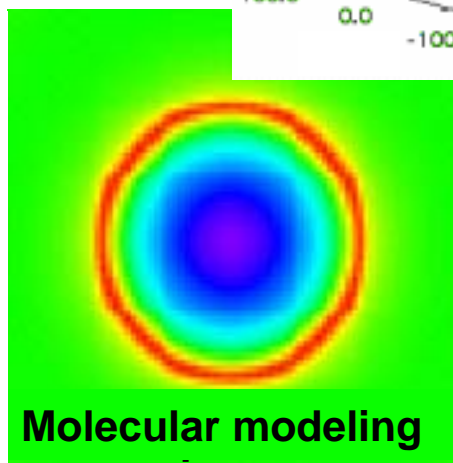
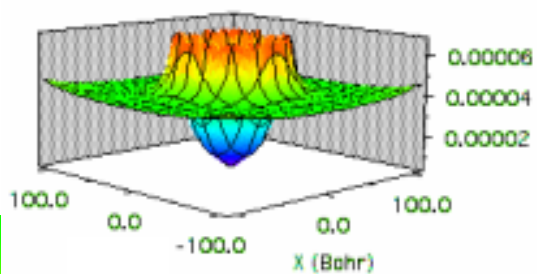


BASIN-SCALE REACTIVE TRANSPORT

Santa Clara Valley Water
District, Zone 7, U.S. Geological
Survey

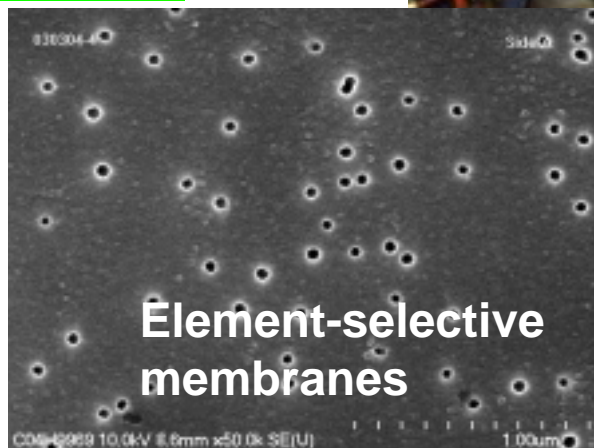


LLNL is creating energy-efficient, selective removal technologies: Especially applicable to rural communities



Molecular modeling

Application: Water treatment facility at Grayson, CA (City of Modesto Water Utility)



Element-selective membranes



Perchlorate

Arsenate



Nitrate

Tamoxifen



Improving the Economics of Renewable Power



Integrating water treatment and mineral recovery at Mammoth Lakes, CA

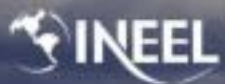


Colloidal silica precipitate

Potential value of minerals in
geothermal fluids at Mammoth
(gross annual, in millions)

Silica	\$8.6
Lithium	\$1.5
Rubidium	\$90
Cesium	\$100
Tungsten	\$2.6





Pacific Northwest
National Laboratory



Energy-Water Nexus Team: 11 national laboratories and EPRI, working together to develop support for a national energy/water security program.

THE **ENERGY** ~ **WATER** NEXUS

a strategy for energy and water security

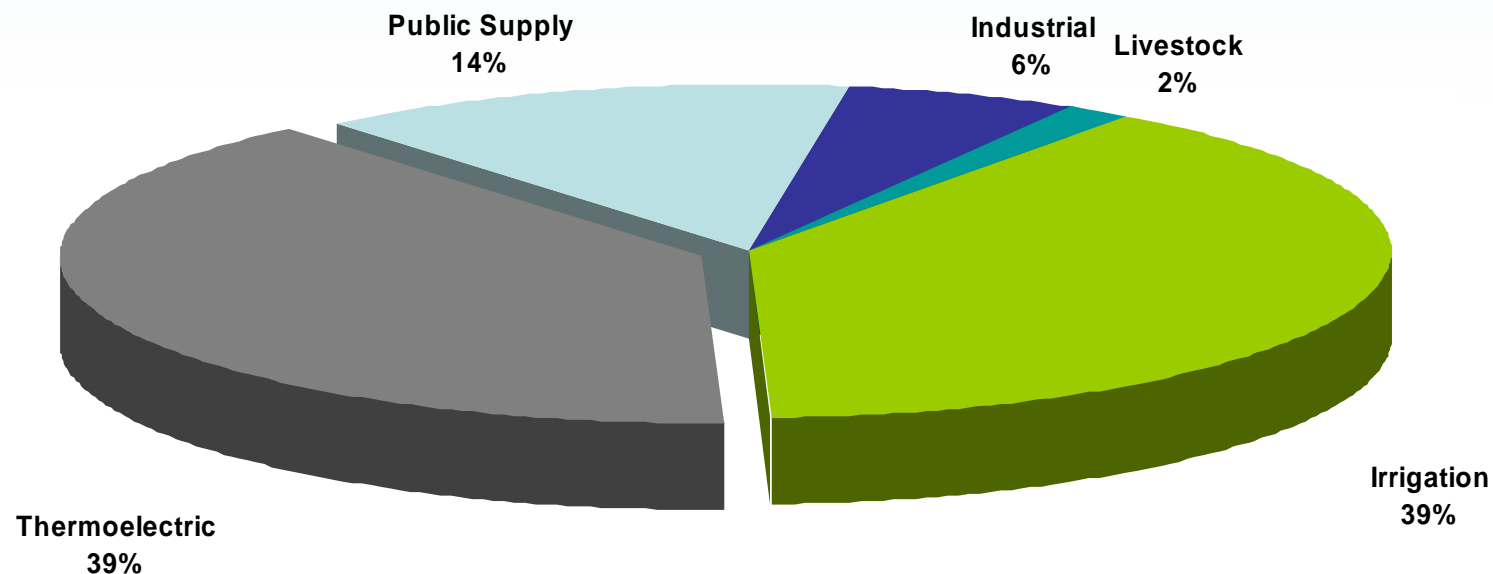
Competition For Water Is Limiting Energy

- Georgia Power Loses Bid to Draw Water from Chattahoochee
 - *Miami Herald*, February 2002
- EPA Orders Mass. Power Plant to Reduce Water Withdrawals
 - *Providence Journal*, RI, July 2002
- Idaho Denies Water Rights Request for Power Plants
 - *U.S. Water News Online*, August 2002
- Duke Power Warns Towns in Charlotte, N.C., Area to Cut Water Use
 - *The Charlotte Observer*, NC, August 2002
- Company Ends Fight for Power Generator on NJ-NY Border
 - *The Record*, NJ, September 2002
- New Mexico Utility Plans to Increase Power, Use No More Water
 - *Albuquerque (NM) Journal*, June 2003
- Pennsylvania Nuclear Power Plant to Use Wastewater from Coal Mines
 - *The Philadelphia Inquirer*, July 2003
- Utilities Warn of Power Crunch if Flows Are Cut
 - *Greenwire*, July 2003



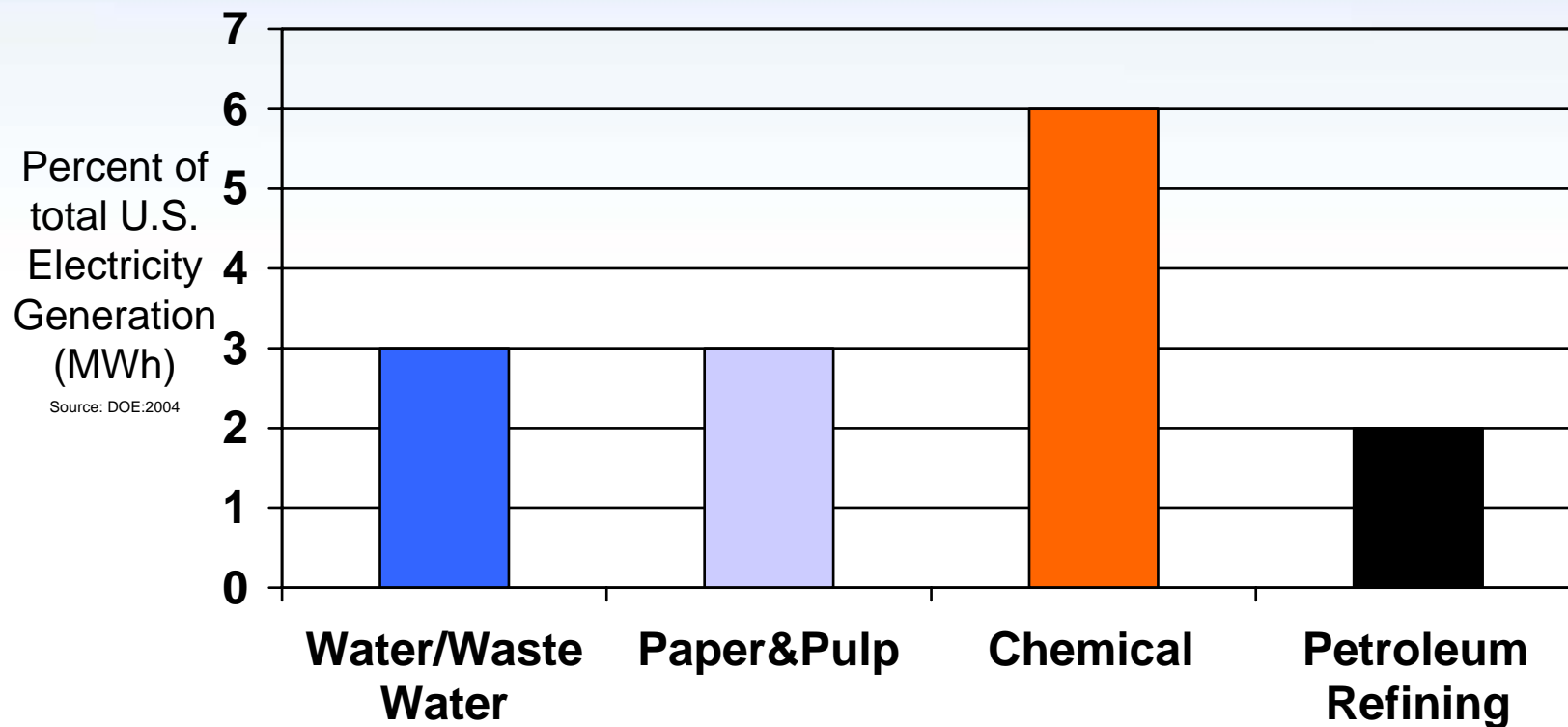
As Much Freshwater Is Used For Producing Electricity As For Irrigation

Estimated Freshwater Withdrawals by Sector, 2000



Source: USGS Circular 1268, March, 2004

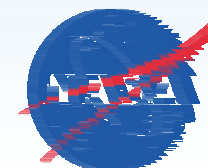
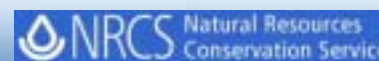
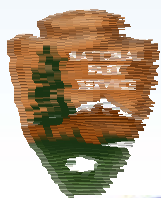
As Much Energy is Used for Water/Wastewater as for Other Major Sectors of the U.S. Economy



Many Federal Agencies Address Water, But Gaps Exist at the Energy~Water Nexus

*No other agency has overall
programmatic responsibility for:*

- Water-related impacts on energy policy
- Water used by energy production
- Energy used by water systems



US Army Corps
of Engineers®



THE **ENERGY-WATER** NEXUS
ENERGY-WATER
a strategy for energy and water security

ANL • BNL • INEEL • LBNL • LLNL
LANL • NETL • NREL • ORNL • PNL • SNL

The Energy~Water Nexus: A National Concern Needing DOE Attention

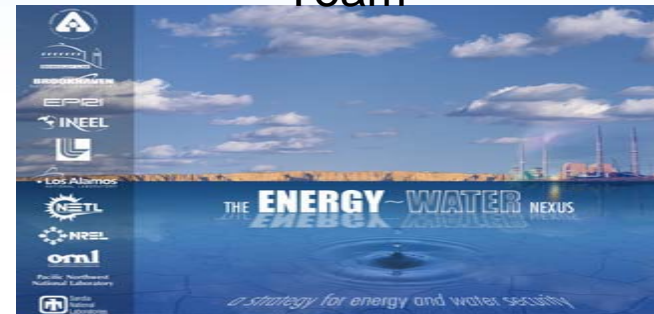
- DOE's Energy Strategic Goal is at risk
 - *"promoting a diverse supply ... of reliable, affordable and environmentally sound energy"*
- DOE's Science Strategic Goal is directly applicable
 - *"to protect our national and economic security by providing world-class scientific research capacity"*

DOE has unique scientific, technology development and assessment capabilities that are currently being applied to address parts of complex energy~water nexus challenge

DOE Labs are Identifying Science and Technology Needs for Energy and Water

- Regional workshops, coordinated laboratory activities
- DOE (LERDWG) discussion February '03
 - First meeting to develop an Integrated approach
- Energy~Water Nexus Team Meetings:
 - Washington, May '03
 - Chicago, October '03
 - Dallas, January '04
 - Washington, February '04
 - Berkeley, March '04
 - Argonne, August '04
- Spring and Summer 2004, informational briefings to DOE, other federal offices
- Request for assistance in developing national program

Energy~Water Nexus Team



Representation from all DOE Multi-Program Laboratories

Critical Outcomes from a New Program: Assessment, Science & Technology Products for Energy Security

- **Quantification** of water needs for sustainable energy development
- **Prediction** of gaps in regional water availability and energy sector demand (seasonal-to-decadal time scales)
- **New science and technology** for advanced water treatment, energy-water conservation, and reduced environmental impacts
- **Science basis** for energy-water policy decisions
- **Information and decision tools** to define the interdependencies between water, energy and other critical infrastructures
- **Solutions** to emerging conflicts among environmental quality, water allocation, and energy development

Growing Awareness Exists in Congress on the Need for a DOE Program

- **Energy Policy Act of 2003**
 - **Section 961, Subtitle (f) Water and Energy Sustainability Program**
 - **Calls for DOE to:**
 - **Assess**
 - Future water resources needed for energy
 - Future energy needed for water purification and treatment
 - Use of impaired waters by energy
 - Technology for water use efficiency
 - **Develop Program Plan**
 - Scientific and technology requirements
 - Decision tools
 - Demonstration projects
 - Information transfer

Latest Congressional legislation concentrates on technology development

- **National Water Technology R&D Program, (S.2658, Domenici, Bingaman, Craig, Durbin, Feinstein, and others)**
 - Establishes within DOE a research and development program to improve access to existing and untapped water resources
 - Major elements include:
 - Focus on water supply technology development and technology transfer
 - Regional Centers, focused on Labs/University partnerships
 - Specified R&D themes for each Lab/University partnership
 - Block grants to regions, plus competitive and cost-shared funding
 - Policy Institute (UNM)
 - Program Coordinator (SNL) and Advisory Panel
 - Ultimately, \$225M/yr for 5 years
- **Companion House Bill (H.R. 4835, Pombo, Calvert, Pearce, Wilson, and others)**
- **December: *Roadmapping appropriation***

LLNL is named the National Laboratory Lead for the Pacific Region Center in S.2658 and HR.4835



LLNL's capabilities are well aligned with the Pacific Region themes in S.2658 and HR.4835

Pacific Regional Center

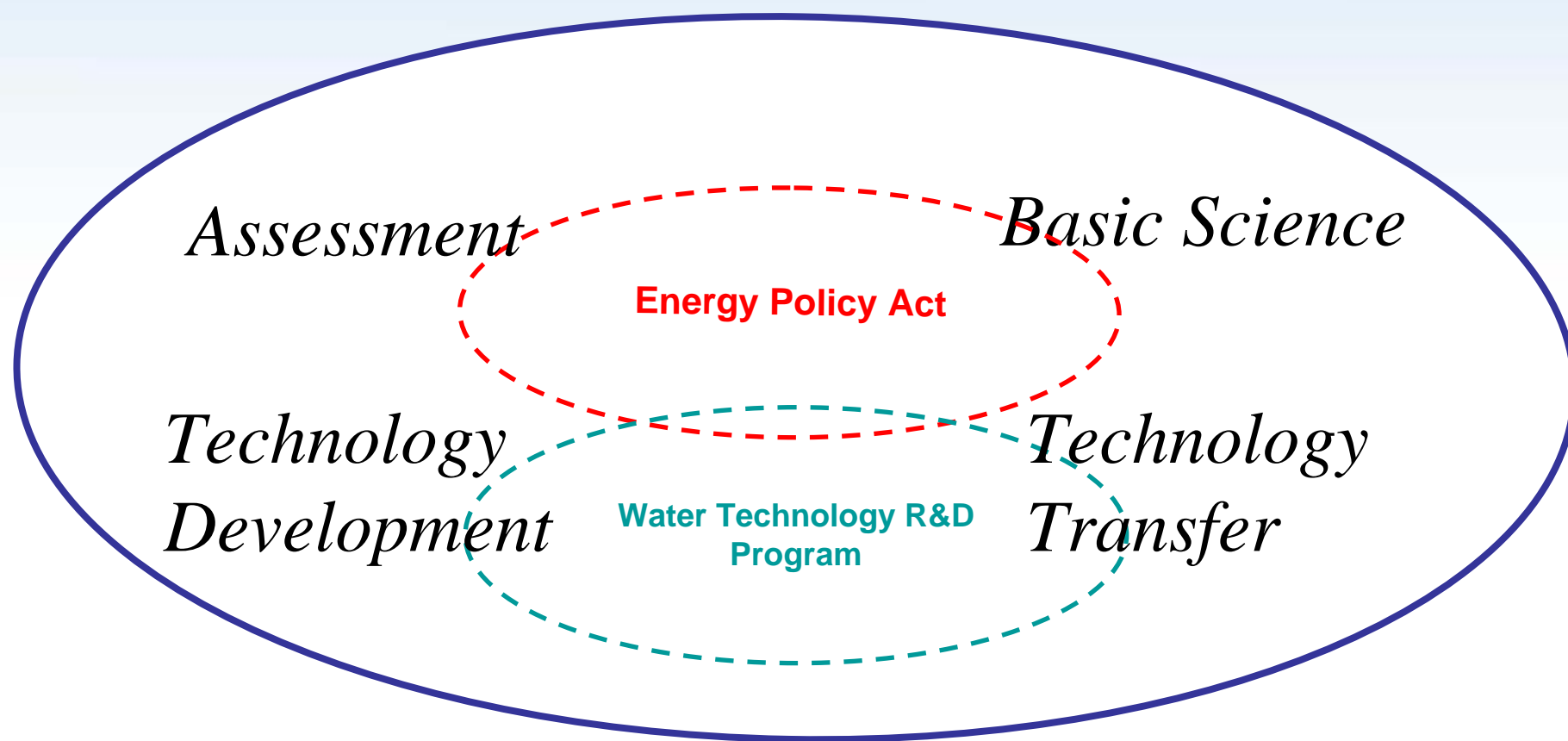
- Point of use technology, water treatment and conveyance energy reduction
- Co-located energy production and water treatment
- Water reuse for agriculture



Recent Activities on the Energy-Water Front:

- June 16-17, 2004: Congressional briefing
- July 14-15: Bills introduced
- August 17-18: Review of Program content
- September: Hearings planned
- December: Roadmapping appropriation
- January, 2005: Refining legislation and implementation plan

**The Energy~Water Nexus requirements are
broader than new proposed legislation**



Energy-Water Nexus Needs

**The Energy~Water Nexus requirements are
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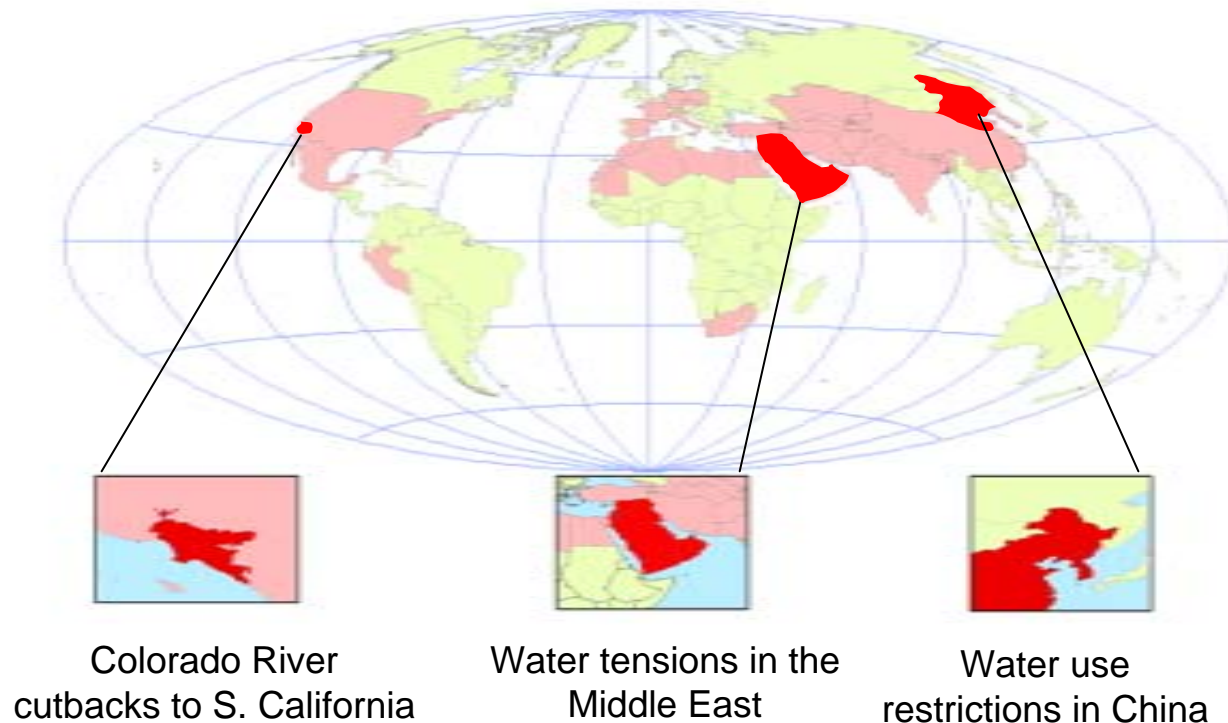
*The Energy-Water
Relationship Whitepaper will
identify key issues for
California*

Energy-Water Nexus Needs



The world is on the verge of a major water crisis

- At least 1.1 billion people (*nearly 25% of the world*) lack adequate supplies of drinking water
- 2.3 billion people lack adequate sanitation; 5-7 million die annually from water-related diseases
- 4% decrease per year due to contamination and depletion of aquifers
- Projections: severe shortage for 2.7 billion people by 2025, *a third* of world's population by 2050



Recent Activities on the Energy-Water Front:

- **June 16-17, 2004:**
 - Congressional staff briefing by EWN Team
 - Meeting with Domenici staff regarding Water Technology R&D Act
- **July 14-15:**
 - Congressional Open House: Water Technology R&D Program
 - Press Conference by Domenici, Bingaman, Pombo and Calvert
 - Introduction of S. 2658 and companion H.R. 4835
- **August 17-18:**
 - EWN Team responded to request to review technical content of Water Technology R&D Program
 - Compared elements of Water Technology R&D Program to the broader Energy Water Nexus
- **September:**
 - Congressional hearings on Water Technology R&D Program postponed
- **December**
 - Roadmapping appropriation
- **January, 2005:**
 - Refining legislation